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CITRUS FRUIT GROWING IN THE GULF STATES.

BY

P. H. ROLFS,

Pathologist in Charge of Subtropical Laboratory, Vegetable Pathological and Physiological Investigations, Bureau of Plant Industry.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., October 20, 1905.

SIR: Many requests are received at the Department of Agriculture for information on the methods employed in growing oranges and other citrus fruits, and it is important that the Department be able to supply the desired information as fully as possible. In order to furnish this information in concise form, Prof. P. H. Rolfs, Pathologist in charge of the Subtropical Laboratory, Vegetable Pathological and Physiological Investigations, Bureau of Plant Industry, has prepared this bulletin on "Citrus Fruit Growing in the Gulf States," which will be of service, it is believed, to many prospective citrus growers and to very many planters now engaged in the industry. I have the honor to recommend that the paper be published as a Farmers' Bulletin.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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CITRUS FRUIT GROWING IN THE GULF STATES.

INTRODUCTION.

The following pages were written for the purpose of giving brief and concise directions for the production of a citrus orchard, the necessity for such a bulletin being apparent from the numerous letters asking for information on this subject received by the Department of Agriculture. It has been the aim of the writer to furnish information to meet the needs of many inquirers rather than to prepare a complete treatise on this industry.

The growing of the finest citrus fruits is a horticultural accomplishment not surpassed in any line of the art. There are very few agricultural occupations that require an equal amount of judgment, and very few that give as remunerative a return for the mental outlay. Everyone who is willing to pay the price, either in labor or in dollars, can grow oranges and grapefruit, but only he who is so constituted as to derive pleasure in exercising his mental faculties to their fullest extent can produce fruit of the finest quality. There is a very long series of conditions, from the choice of the stock into which the bud is to be placed to the delivery of the package of perfect fruit to the consumer, which must be met successfully. If any one of these links in the chain is broken, first place can not be attained. Good judgment with previous knowledge must be exercised in the choice of the stock, the bud, the soil, and the location of the orchard, in the cultivation and fertilization of the crop, in the treatment of fungous and insect diseases,[a] in picking and packing the fruit, and in selecting a market for its disposal.

The production of the finest oranges requires years of most careful study and as diligent attention as the most intricate business operation.

[a] Fungous and insect diseases, however, are not here discussed, since to treat them adequately would unduly increase the size of this bulletin. For an account of insect enemies, see Farmers' Bulletin No. 172, "Scale Insects and Mites on Citrus Trees."

Unless the citrus grower is in full sympathy with his surroundings and in love with his work, he will as surely fail to produce the best results as would be the case in any other occupation.

CLIMATE.

In general it may be stated that in all regions in which the temperature does not fall below 18° above zero nor rise above 100° F., and where there is sufficient moisture, citrus fruits may be produced. There are, however, localities within these limitations that can not be said to be good citrus-growing sections. In some places, although the trees grow luxuriantly, heavy rainfalls occur at the time when the fruits are maturing, making it impossible to gather and market them. In others the conditions for vegetative growth are so favorable that very little fruit sets. Regions that are excessively dry may, however, be utilized for citrus culture when irrigation can be practiced. The more nearly the northern limit of the citrus belt is approached, the more sprightly and deliciously flavored the fruit becomes, some of the very best fruit being marketed from areas where the trees every winter are in danger of being frozen out.

The ideal climate for citrus growing is one in which the rainfall occurs after the fruit has been shipped and before the new crop begins to ripen. The rainfall should not be excessive, certainly not more than 50 to 70 inches annually, and the winter temperature should not go below 26° to 27° F. of continued cold, though a lower temperature may be withstood for an hour or more without killing the trees. Orange trees in a thoroughly dormant condition can withstand a temperature as low as 24° F. if this is not continued for more than a few hours at a time. A very sharp turn to 18° F., if for only a few hours, will entirely defoliate trees in the most dormant condition, while it is likely to kill the larger proportion of those in active growth. Small trees under 8 to 10 feet high, with poorly protected trunks, are very apt to be cut to the ground under these conditions. Sometimes snow falls and remains on the trees for some hours without seriously damaging orange trees; but this is of rare occurrence.

SOIL.

It will be shown under the heading "Varieties" that citrus trees are exceedingly variable, and consequently will readily adapt themselves to almost any kind of soil in which plants can grow. Varieties of citrus grow upon the sticky, adobe soils of Mesopotamia, upon the alluvial soils of the lower Mississippi, upon the fertile soils of the West India islands, upon the dry soils of Arizona and California, and upon the poor, sandy soils of Florida. There is probably no other

genus of fruit trees in which the species are so plastic as to adapt themselves to almost every possible gradation of soil. It should not be inferred, however, that every variety of the genus can be grown upon all of these different kinds of soil, for it is absolutely necessary to choose the particular variety which is adapted to any peculiar soil.

While the rich, alluvial soils produce citrus trees of rank growth which often bear enormous crops of fruit, the finest and highest priced fruits are produced upon the nearly sterile soils. In fertile soils the plant food is seldom properly balanced and present in the condition best suited for producing the finest fruits, nor is it possible to influence the contents or quality of the fruit by applying different forms of chemical fertilizers. If, therefore, a field is normally sufficiently fertile to produce a citrus crop for an indefinite number of years, it is usually impossible to influence the quality of fruit markedly by means of fertilizers. Upon soils which are nearly sterile, however, trees may be started and fed with just such chemicals as will produce the finest quality of fruit. It therefore happens that soils which formerly were considered absolutely worthless for agricultural purposes are now made to produce large crops of most excellent fruit.

SITE OF THE GROVE.

Immediately upon deciding that one wishes to plant a grove he should select the best site that can be procured. A great many questions arise in determining where a grove shall be located. A few of these are discussed below.

DISTANCE FROM TRANSPORTATION LINE.

The ultimate object being the selling of fruit at a remunerative figure, it becomes necessary to locate a grove within a reasonable distance of some line of railroad or water transportation. The distance which it will be profitable to transport fruit by wagon will depend largely on the condition of the roads.

Another determining factor in the matter is the cost of the land. Even a grove of moderate-sized trees should produce a thousand boxes of oranges to the acre. Allowing 50 boxes to a load, this would require 20 trips to the transportation station. If a grove were located 3 miles away from the station, it would probably take one man with a two-horse team six days to haul this fruit. If located one-half that distance, it would require only three or four days. Allowing about $4 a day for this work, the hauling of the fruit from the more distant grove would increase the cost about $8 per acre, which amount must be charged against the original cost of the land. From this

the intending purchaser can readily calculate how much more he can afford to pay proportionally for land in close proximity to the railroad station.

CHARACTER OF THE SOIL.

The variation of the soils in the West Indies and in Louisiana, Mississippi, and California is not so sharply marked as that in Florida. There are, however, characteristic soils in each of these regions that are better than others. In all sections a soil must be chosen that is not underlain with a heavy substratum known as "hardpan." The land should be elevated sufficiently to permit free drainage, and, in the sections where irrigation must be practiced, should be so located that water can be easily supplied.

In Florida the soil usually known as hammock land is preferable for orange growing. This, however, is of limited extent and frequently is so far removed from transportation lines that it is not profitable to use it. The second grade is called piney woods land. Groves properly located on this type of soil and managed by intelligent superintendents frequently give the very best returns. It is upon this land that most of the orange groves are located. The cabbage palmetto hammock, if sufficiently high to permit natural drainage, also makes excellent land for citrus growing.

FROST PROTECTION.

After determining that the desirable features specified are to be found in the location under consideration, it is very important to see that the land is well protected from the occasional frosts which visit the citrus-growing sections. Frost protection is imparted by large bodies of water, such as make citrus growing in Louisiana and Mississippi possible, and in Florida near the lakes in the central part of the State, along the Indian River on the east coast, and on Tampa Bay. In the West Indies and the southernmost part of Florida this factor does not enter into consideration. In fact, it seems that those places in the West Indies which are subjected to the lowest winter temperature produce citrus fruits of the highest excellence. The temperature in the vicinity of Mandeville, Jamaica, is said to go as low as into the fifties during winter nights, and yet this is probably the best citrus fruit section on the island.

PROTECTION FROM HIGH WINDS.

A location chosen so as to combine all the qualifications already mentioned may still be undesirable if it is exposed to the force of high winds, which may occur in any portion of the country. It is quite impossible to protect a grove against tropical hurricanes, but the more

common high winds of annual occurrence must be considered. They carry off the moisture and bring with them a dry, parching air which is injurious to citrus trees, and they are also very likely to cause "thorning" or to mutilate the fruit in other ways. Sometimes it becomes necessary to erect artificial wind-breaks for protecting a grove not well located. These artificial wind-breaks may later be supplanted by some natural growth that can withstand the force of the wind.

RAINFALL.

The amount of rainfall needed to produce a crop of citrus fruits depends on various factors; prominent among them are character of soil and humidity of atmosphere. Where there is a deficiency of moisture it may be supplied by irrigation, but a superabundance of moisture can be controlled only in a measure by drainage. In the humid portions of the United States and in the rainy sections of the West Indies heavy rainfalls frequently occur at the time when the fruit should be marketed or when the trees should be dormant preparatory to blooming. As these conditions can not be corrected, citrus orchards should never be planted in regions where fall or winter rains are prevalent. This is especially true of the rainy side of most islands in the West Indies group.

VARIETIES.

The group of plants which is designated by the generic term "Citrus" is fairly well circumscribed, but when it comes to a segregation of the different species and varieties scientists do not all agree. While it may be of interest to the scientific plant breeder to know just what the classification is, to the practical grower of fruits who wishes to get a large return for his labor it makes very little difference whether the product belongs to one variety or another. The results of the various attempts to classify the plants which fall under the general term "Citrus" vary exceedingly, and various differing opinions regarding their scientific relations are held by scientific investigators. There are therefore a number of different classifications. In the following table the writer has adopted the classification worked out by Dr. Herbert J. Webber in the Cyclopedia of American Horticulture.

BOTANICAL AND HORTICULTURAL CLASSES OF THE GENUS CITRUS.

Botanical species.	Botanical varieties.	Horticultural races.	Horticultural varieties.
I. *Trifoliata*			Trifoliatus.
II. *Aurantium*	*amara*		Sour.
			Bitter sweet.
	bergamia		Seville.
			Bergamot orange.
	sinesis	The common oranges	Bahia.
			Valencia.
			Homosassa.
			Pineapple.
			(Also other varieties.)
III. *Nobilis*		The mandarin group	Satsuma.
			Citrus (mandarin).
			Dancy (tangerine).
			Oneco.
			King.
IV. *Decumana*		Pomelo (grapefruit)	Royal.
			Pernambuco.
			Triumph.
			(Also other varieties.)
		Shaddock	Paradise.
			Forbidden Fruit.
			(Also other varieties.)
V. *Japonica*		Kumquats	Nagami.
			Marumi
			(Also other varieties.)
VI. *Medica*	[illegible]	Citron	Corsican.
			Lyman.
			Orange.
			(Also other varieties.)
	[illegible]	Lemon	Lisbon.
			Villa Franca.
			Sicily.
			Eureka.
			(Also other varieties.)
	[illegible]	Lime	Imperial.
			Mexican.
			Persian.
			(Also other varieties.)

SELECTING VARIETIES.

Experience has taught that no variety of citrus is preeminently useful for all portions of the world where this fruit is grown. As an illustration we have the Bahia, or Washington navel orange, which is preeminently adapted for California, but of little value in Florida or the West Indies, since it produces only a small crop except on rough-lemon stock, which stock is only adapted to a restricted area. Certain varieties of pomelo have exquisite flavor when fruited in Florida, but are not of the same excellence when grown in California. The pineapple orange and the Indian River orange are among the finest of fruits when grown in the sections where they originated, but when produced in Jamaica they can not be said to have superior qualities.

It becomes necessary, therefore, to test the particular variety in the section into which it is to be introduced. Some of the varieties are excellent in places far removed from one another, as is illustrated by the Satsuma, or onshu, an introduction from Japan, and the Bahia orange, which was brought from Brazil by the United States Department of Agriculture and is now so extensively grown in California. The last-named variety produces fruit of excellent quality

when grown in Florida, but, as stated, is not prolific except on rough-lemon stock. Frequently the most important varieties of citrus for any given locality are those which have originated as seedlings in that section, and occasionally they may arise as bud varieties. An illustration of a variety arising as a bud variation is the Surprise navel, originating in Mr. E. S. Hubbard's grove at Federal Point, Fla., from buds received from California. Seedlings, as a rule, "sport" or are exceedingly variable; they, however, come true to seed within certain limitations. So far as known, a pomelo can not originate from an orange seed except where an orange flower is pollinated from a pomelo, and it is then not a true pomelo. Seedlings from the mandarin group reproduce a typical mandarin fruit. Seedlings from the sweet orange produce a typical sweet orange. Seedlings from pomelos produce pomelos of varying qualities.

The total number of varieties of citrus fruits that have been catalogued and described would run up into the thousands. Nearly every one has some peculiar merit for a particular locality. Out of the many thousands a few selected ones are of general value, and can be planted with safety over a considerable area. The following very brief list gives some of the varieties for the localities mentioned:

Florida.—The Florida State Horticultural Society has divided the State into four horticultural sections known as western north Florida, eastern north Florida, central Florida, and south Florida.

Eastern north Florida includes "that part of the State between the Aucilla River and a straight line drawn across the State from the mouth of the St. Johns River to Cedar Keys."

The following citrus fruits are considered especially adapted for this region: Of the sweet orange group, Parson Brown and Sweet Seville; of the tangerine group, the Satsuma; of the kumquat group, the Marumi and Nagami.

Central Florida includes "that part of the State between the line above referred to and the counties constituting south Florida."

Of the sweet orange group well adapted to this section may be mentioned Centennial, Tardiff, Homosassa, Jaffa, Majorca, and Parson Brown; of the mandarin group, Satsuma, China, Dancy, and King; of the pomelo group, De Soto, Duncan, Excelsior, Hall, Marsh, Pernambuco, Royal, and Standard.

Shaddocks and citrons are not grown as commercial fruits, and Nagami is the leading variety of kumquat for this section.

South Florida includes the following counties: Brevard, Dade, Monroe, De Soto, and Manitee.

The sweet oranges recommended for this section are the Bahia on rough-lemon stock, Tardiff, Homosassa, and Majorca; of the mandarin group, China, Dancy, and King; of the pomelo group, De Soto, Duncan, Excelsior, Hall, Marsh, Pernambuco, Royal, and Standard.

Shaddocks are not grown commercially, and are found only as ornamentals or novelties. In the kumquat group the leading variety is the Nagami. Citrons are grown only as occasional specimens.

Lemons are not grown as extensively in Florida as in California. There are, however, some good orchards of this fruit, the varieties principally produced in south Florida being Belair, Genoa, Imperial, Sicily, and Villa Franca.

On the keys and the adjacent coast considerable quantities of limes grow without cultivation and are apparently naturalized. The Department of Agriculture has distributed various importations of limes into south Florida, and nearly all of these varieties do very well. The peculiar demands of the market, however, are such as to make lime growing unprofitable. Nevertheless, very high prices are paid for the limes which are gathered from trees occurring spontaneously on the coast and keys. This lime is generally spoken of as the Key lime. It is a very small fruit and intensely acid, and usually contains many seeds. This same lime when taken to the mainland and put under cultivation produces a large fruit, with very thick, rough skin, approaching in size and appearance that of the usual lemon. Limes of this size do not meet with ready sale.

Louisiana and Mississippi.—The citrus-growing section of Louisiana and Mississippi occurs in the region closely bordering on the Gulf. In Mississippi it is near Biloxi, and in Louisiana it is south of New Orleans.

In these sections the common sweet orange grown is known as the Creole. This, strictly speaking, is not a variety, but an assemblage of seedling oranges that have been cultivated in this region for some time. Of the mandarin group Satsuma and China are the leading varieties. Of the pomelo group only a few are grown, these being the earliest varieties, such as Royal and Triumph.

Porto Rico and the West Indies generally.—Citrus growing throughout the West Indies is in a rather formative state. The efforts at systematic work in this line have not been carried forward with the same degree of vigor as in California and Florida. Nearly all the varieties recommended for south Florida may be planted with more or less confidence in this region. After years of experimenting in this region local varieties will doubtless develop which will prove better than some of the sorts now introduced on these islands.

PREPARATION OF THE LAND.

As a rule the field chosen to be planted out to an orange grove is land with a native growth upon it, which has to be removed. Usually the land is covered with forest trees. Various devices have been used

for reducing the amount of labor necessary to get rid of this native growth, but up to the present time no substantial or decided progress has been made in the methods of clearing land. The most of the work is done by main strength and muscular labor. Where the native growth happens to be some form of hard wood, it is the usual practice to remove the trees and stumps. Some advantage is frequently obtained by the use of dynamite or other explosives in loosening the stumps. Where the native growth is pine woods or palm trees, the necessity for removing the stumps is not so great, though in the case of the former the stumps are usually taken out. In cabbage palmetto hammocks some of the trees are left and used as nurse plants for a few years. The ideal course is to remove all trees, shrubs, and other forms of vegetation from the land and to clear it of all rocks and any other débris that may be found. Then the land may be broken up and put into a first-class state of tilth, which will permit careful staking and planting.

SETTING OUT.

Usually the prospective orange grower buys trees from a nursery and sets them out as soon as the field has been cleared, wishing, of course, to get the trees on the land as soon as possible and to hasten the time when he may be selling fruit. Sometimes this is by no means the most profitable procedure. Land especially rich in organic matter and heavily matted with roots from the native growth would be decidedly better for having produced a crop or two of vegetables before the grove was planted. If for any reason it is not desirable to grow vegetables, a crop of weeds grown on it for a year would do much to sweeten the land preparatory to receiving the trees from the nursery. A crop of cowpeas or velvet beans would be preferable, however.

The number of trees to be set out to the acre depends on the variety selected and the character of the land. Large-growing citrus trees, such as pomelos and the Bahia and Tardiff sweet oranges, should not be set closer than 100 to the acre, and on first-class soil 75 are enough. Smaller-growing varieties, such as the mandarin group of oranges and the limes, should not be set closer than 200 trees to the acre. The character of the land will also need to be considered in setting out a grove. In a sandy loam, rich in organic matter, trees grow much more vigorously, and in consequence should be set farther apart. In the heavy clay soils trees grow less vigorously and may be set nearer together.

TIME AND MANNER OF SETTING OUT.

The time of setting out trees from the nursery will depend on the location and the conditions. In the West Indies and south Florida trees may be set out at any time of the year when the land is ready and there is sufficient moisture to favor their growth. In central Florida, the spring (February and March) is preferable. The same is true of north Florida, Louisiana, and Mississippi. In the extreme northern portions of the citrus-growing section it is usually better to wait until the danger of freezing weather is past. This will bring the date up to about the latter part of February. In setting out trees from the nursery, care should be taken to injure the roots as little as possible. Where trees can be taken up with a considerable ball of earth and transplanted in this way, they may be set out without any apparent check in growth. This, however, is not usually practicable in sandy soils.

When the trees are taken up the roots should be carefully protected by means of wet cloths or moist moss and the trees set in holes already prepared for them. If the ground is not already very moist the addition of one or two pails of water will usually puddle the roots and cause the trees to grow promptly. At the time of setting out, the tops should be cut back to correspond closely to the condition of the roots. The favorite size of tree to set out is one that has grown about 4 feet tall in the nursery and has several branches. Such trees are usually about an inch or an inch and a half in diameter at the crown.

CATCH CROPS.

As soon as the field has been set to a grove, cultivation may be begun. The kind and amount of cultivation will be determined by the character of the soil. Light, sandy soil should have shallow but careful cultivation. Heavy clay soils need thorough and deep working. Where there is an abundance of moisture supplied naturally to the soil, other crops may be grown to advantage between the orange trees. Where the soil is inclined to be dry and irrigation has to be practiced, this is of doubtful utility in the dry season. During the winter, vegetables may be planted and cultivated as in ordinary fields with decided advantage to the orange tree unless the land is too dry. Leguminous cover crops may be planted as soon as the spring and summer rains begin. When fall droughts occur the cover crops will have to be removed to conserve the moisture of the soil. Cultivation should then be resumed. If the soil is inclined to be sterile the cover crop should be used as a mulch for the trees. If the ground is sufficiently fertile to permit it, the cover crop can be utilized for hay.

PRUNING.

"To prune or not to prune; that is the question." At many of the meetings of the horticultural societies the question of pruning has been vigorously discussed. There are many good reasons for pruning trees; on the other hand, there are reasons why trees should not be pruned. The question, then, must be decided by each individual. One point, however, has been very well settled, and that is that low-headed trees are preferable. Twenty-five or thirty years ago it was a common practice to have citrus trees trimmed high enough to permit a man to drive a cultivator under the branches. The severe cold of several winters has caused this custom to be very largely abandoned. In the southern part of Florida, where there is no danger from frost, it has been found that shading the ground by the limbs has been very beneficial to the grove. Another important advantage in low-headed trees is that the fruit may be gathered much more cheaply than from tall trees.

Nearly all orange growers will agree that the pruning out of dead and worthless branches is of benefit to the tree. The extent to which sound wood is pruned out, however, varies with the notions of the individual grower. Some of the most extensive and best growers in Florida practice no pruning at all. Diseased branches should always be cut out, removed from the orchard at once, and burned. Sprouts that start from below the bud must be removed, and this should be done as soon as possible. Water sprouts need not and ordinarily should not be removed. There are conditions under which removal is entirely proper, but the very common practice of removing them simply as a pastime is a very harmful occupation. The fact that a water sprout appears shows that the tree is in a position to elaborate more reserve material than can be elaborated by its present leaf area. After a year or two years these water sprouts produce an abundant crop.

A citrus tree should be kept in a low, compact form, but violent pruning, such as is often practiced in deciduous fruit orchards, is not only unnecessary but often absolutely harmful. There are special cases, such as lemon orchards, and there are some regions in which trees must be mutilated to make them fruit; but that does not affect the general rule that citrus trees should be sparingly pruned or not at all.

FERTILIZERS.

Under the general heading of fertilizers, materials which may be employed to enrich the soil or cause it to produce a heavier crop may be considered. Ordinarily, the term "fertilizers" is restricted to such as are considered commercial articles, while the term "manure" is ap-

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plied to organic offal and refuse accumulating on the farm. In some parts of the United States the term "guano" has been used to designate commercial fertilizers. Cover crops which are grown on the land for the purpose of enriching the soil are frequently called "green manures."

The kind of fertilizer required to produce a heavy crop of oranges varies greatly. In the West Indies, Mexico, Mississippi, Louisiana, and California the general constitution of the soil is so variable that no hard-and-fast rule can be given. In fact, in many cases it is doubtful whether the results desired attend the application of any or all the elements usually needed as plant food. While fertile soils produce trees of vigorous growth which often bear large crops of fruit, the possibilities are necessarily limited to what Nature will do; but in soils where one or more of the elements of plant food are present in deficient quantity, the modeling of the fruit and the production of excellent qualities are more completely under the control of the skilled horticulturist.

The conditions under which the report referred to in the quotation below was made by Aliño (Experiment Station Record, Vol. XIII, p. 455) are somewhat similar to those found throughout a large portion of Florida:

Analysis of orange trees.

	Total ash.	Nitrogen.	Phosphoric acid.	Potash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Fresh fruit	3.21	0.38	0.40	0.38
Leaf	6.00	.70	.10	.38
Wood	7.00	.70	.50	.73

On the above basis it is calculated that a hectare [approximately 2¼ acres] of oranges containing about 250 trees and yielding, when in full bearing, 30,000 kg. [66,000 pounds] of fruit, would remove from the soil 114 kg. [250 pounds] of nitrogen, 129 kg. [284 pounds] of phosphoric acid, and 114 kg. [250 pounds] of potash. If these elements are returned to the soil the equivalent of 760 kg. [1,672 pounds] of nitrate soda, 705 kg. [1,544 pounds] of superphosphate of lime, and 225 kg. [495 pounds] of sulphate of potash will be required. This formula is intended for soils composed mainly of siliceous sand, with some lime and clay, having a good depth and capable during the summer of receiving copious irrigation. This is considered by the author [Aliño] the ideal soil for oranges. On other soils this formula can not be strictly adhered to.

The evil effects attributed to an excess of nitrogen are that it produces an exuberant growth of wood and foliage, while the resulting fruit is very coarse and thick-skinned, with little sugar or aroma and of bad keeping quality. The time of ripening is also retarded. With an excess of phosphoric acid the fruits are small, numerous, well flavored, and aromatic, with thin skin and poor pulp. "When potash is superabundant the tree does not grow very large, but the fruit is juicy, sweet, and of pleasant flavor."

As to the most desirable forms of fertilizers, the author prefers sulphate of ammonia in light soils and in those charged with organic matter. Nitrate of soda is better

applied to heavy soils. Superphosphate of lime is considered the best of the phosphate fertilizers. "Only in gypseous soils and those humid and rich in organic residues should the phosphate 'Thomas' be employed." The sulphate and chlorid of potash may be used indifferently, though the sulphate appears to give more delicacy and fragrance to the fruit. In rather limy soils the use of sulphate of iron is considered beneficial. In those with a little lime, and especially if inclined to be rough and clayey, the use of gypsum is advised.

In fertilizing young trees materials furnishing about one-half the nitrogen and phosphoric acid and one-fourth the potash required for an orchard in full bearing, as noted above, are required. For old trees the following is one formula recommended: Sulphate of ammonia, 300 kg. [660 pounds]; nitrate of soda, 400 kg. [880 pounds]; superphosphate of lime and manganese, 800 kg. [1,760 pounds]; sulphate of iron, 300 kg. [660 pounds]; chlorid of potassium, 25 kg. [55 pounds], per hectare. In the case of orange trees which produce an abundance of wood, leaf, and flowers, with but little fruit, the author believes the defect due either to a deficiency of nutrition or to a deficiency of the phosphates which promote the fecundation of the ovary of the flower, or to a superabundance of nitrogen, "which by excessively expanding the sexual organs of the flower produces its abortion." The following formula is suggested for such trees: Sulphate of ammonia, 75 kg. [165 pounds]; nitrate of soda, 75 kg. [165 pounds]; superphosphate of lime, 1,000 kg. [2,200 pounds]; kainit, 300 kg. [660 pounds]; sulphate of lime, 300 kg. [660 pounds], per hectare. With orange trees suffering from gumming, the use of organic fertilizers, and especially horse manure, should be avoided. The only manure required for trees in the seed bed is the free use of horse manure.

The effect of fertilizing orange trees in Florida with different ingredients has been very thoroughly discussed by Dr. H. J. Webber in the Yearbook of the Department of Agriculture for 1894, pages 193–202. The closing paragraphs of this article are as follows:

Summarizing, it may be said:

(1) By a proper combination of the various elements used in fertilization one can undoubtedly largely govern the quality and flavor of the fruit.

(2) To obtain a fruit with thin rind, use nitrogen from inorganic sources in moderate quantities, with considerable potash and lime.

(3) To sweeten the fruit, use sulphate of ammonia in considerable abundance, decreasing the amount of potash.

(4) To render the fruit more acid, increase the amount of potash and use nitrogen from organic sources.

(5) If it is desired to increase the size of the fruit, as is sometimes the case, apply a comparatively heavy dressing of nitrogen in some organic form and slightly decrease the other elements. In the case of the tangerine and mandarin, where a larger size is usually desired, a heavy dressing of nitrogen fertilizers would favor this end, and is not objectionable unless carried to excess.

(6) Fertilization has an important bearing on diseases.

(7) Die-back, a serious malady, is in all probability the result of overfeeding with nitrogenous manures from organic sources. These manures if used at all should be applied with great caution.

(8) Foot-rot, although not primarily due to improper methods of fertilization, is no doubt considerably influenced by this cause.

(9) Insect diseases are also apparently influenced by the use of fertilizers, organic manures rendering the trees more liable to injury from this source than chemical fertilizers.

INJURIOUS ACTION OF MUCK.

Dr. H. J. Webber writes as follows regarding the use of muck as a fertilizer:[a]

Muck is very commonly applied in considerable quantities either in a raw state or composted with sulphate of potash, etc. Many growers rather fanatically hold to what they term natural fertilization. By this is usually meant giving the tree nourishment in the form in which they suppose it to be derived in nature. It is contended by many that muck is principally decaying vegetable matter, and that as this is the form of nourishment which the trees obtain in nature it must be a good fertilizer to use in cultivation. But it must be borne in mind that orange trees, as we cultivate them, are decidedly not in a state of nature, except that by the cultivation of centuries we have made cultivation and manuring natural conditions which the plant demands. Trees in nature bear fruits for seeds to reproduce the species; on the contrary, we grow fruits for market and favor a seedless variety. We want a smooth, thin-skinned, tender, juicy fruit that will sink in water. Nature does not pay particular attention to these characters, so we watch for freaks and sports, abnormal plants, which have the characters we desire, and when found we render these characters permanent by budding. Our aim in cultivation is not to produce the fruit we find in the wild state, but to modify that fruit to suit our purpose. One of the most efficient methods of accomplishing this is to vary the fertilization.

While it can not be denied that muck has in some cases given excellent results, it must be conceded that its extensive use has usually been of doubtful benefit and often has done positive injury. Groves which have had liberal dressings of muck are frequently much diseased and produce light crops; the oranges are usually coarse, thick-skinned, and sour; the productiveness is often lessened by premature dropping of the fruit; the tendency seems to be to bring on die-back, a disease which is of frequent occurrence in groves heavily fertilized with muck. What has been said of muck applies to a greater or less extent to the various forms of organic nitrogen used. The tendency of all organic manures rich in nitrogen is to produce a large growth which is weak and sickly. Growth and not fruit is stimulated, and the fruit resulting is usually of poor quality, inclined to be large and rough, with a thick rind and abundant rag.

STABLE MANURE OF DOUBTFUL UTILITY.

Regarding stable manure, Doctor Webber says:[b]

Barn manure is largely used by many growers, who still hold to the tradition that chemical manures are injurious to the plants. The benefits of barn manure in an orange grove are in serious question. The fruits produced by nitrogen from this source are, as above stated, usually large, coarse, thick-skinned, with abundant rag, and of inferior flavor. If barn manure is used—and most growers have a limited quantity and desire to use what they have—it should be spread over the grove lightly, so that each tree receives only a small amount. Where such manure is depended upon as the main element of fertilization, liberal dressings of potash should be occasionally applied. This will tend to correct the evils of an overbalanced nitrogenous fertilizer. What has been said as to the effect of muck and barn manure on the quality of the fruit applies equally to the effects produced by

[a] Yearbook of the United States Department of Agriculture for 1894, p. 195.
[b] Yearbook of the United States Department of Agriculture for 1894, p. 196.

cotton-seed meal, blood and bone, tankage, etc. In general, organic fertilizers do not stimulate fruiting to the same extent as the mineral fertilizers. It is probably better economy to apply such fertilizers to annual crops, cereals, garden truck, etc.

COMMERCIAL FERTILIZERS FOR FLORIDA.

The kind and quantity of fertilizer necessary to produce a maximum crop of fine fruit depend entirely upon the soil upon which the tree is growing. Many soils in the citrus regions contain an excess of all the elements necessary for the production of citrus fruits. When fertilizers are applied under such conditions no beneficial effect can be noticed from their use. An orange tree planted upon soil that contains large quantities of the necessary elements usually produces large fruit, but often of an indifferent character. Soils that are deficient in nitrogen, potash, and phosphoric acid can usually have these supplied from such sources and in such quantity as will produce fruit of the desired texture and consistency. It therefore happens that the finest and most delicious fruit is grown on rather sterile soil.

The entire piney woods of Florida may be said to be deficient in each of the three important elements of plant food—nitrogen, potash, and phosphoric acid. Soils are also found in which there is a deficiency of lime, so that frequently an addition of this element will prove of value. The hammock soils are usually sufficiently fertile to produce at least one crop, or even a few crops of fruit, without the addition of fertilizer. These, however, in time become depleted, and the elements of plant food then need to be supplied by substances from a commercial source.

In growing citrus fruits on soils that are deficient in all of the three important elements of plant food, a fertilizer of the following composition is desirable:

	Per cent.
Ammonia	4
Potash	10
Phosphoric acid (available)	6

For growing nursery stock or for trees not of a bearing age the amount of potash in the formula may be reduced 6 per cent, leaving the two other ingredients in about the above proportions.

The quantity of this fertilizer to be applied per acre will depend upon various conditions. About 15 or 20 pounds may be applied to each bearing tree per year, the quantity being decreased or increased from year to year, as results indicate. Calculating this on the basis of 100 trees per acre, 1,500 pounds per acre per year would be used for young bearing trees. Double this amount is very frequently applied, and sometimes three times as much is used.

The following table gives approximately the amount of material needed per acre, in the case of bearing trees, to supply a quantity of

fertilizer equal in fertilizing constituents to 1,500 pounds of the foregoing formula:

		Pounds.
(1)	Sulphate of ammonia	250
(2)	Sulphate of potash, high-grade	300
	Or sulphate of potash magnesia (low-grade sulphate of potash)	550
(3)	Dissolved boneblack	550
	Or acid phosphate, 14 per cent available phosphoric acid	850

In the case of nursery stock and growing trees 2 per cent of the ammonia may be derived from an organic source. This would require approximately the following ingredients:

		Pounds.
(1)	Sulphate of ammonia	125
(2)	Dried blood	100
(3)	Sulphate of potash, high-grade	200
	Or sulphate of potash magnesia (low-grade sulphate of potash)	350
(4)	Dissolved boneblack	550
	Or acid phosphate, 14 per cent available phosphoric acid	850

If there is any tendency toward die-back the dried blood should be omitted, and the amount of sulphate of ammonia increased to 250 pounds. If a quick-acting fertilizer is wanted nitrate of soda (100 pounds) in place of dried blood may be employed.

Citrus growers wishing to compound their own fertilizers should give due regard to the substances from which the different qualities are derived.

Organic ammonia, as found in cotton-seed meal, dried blood, guano, and the various stable manures, is apt to produce a soft, rapid growth, and in certain sections, especially in Florida, is almost certain by continued use to produce die-back.

Nitrate of soda is soon taken up by the trees, but is easily washed out of the soil. Where it is used as the only source of nitrogen it has to be repeated from four to eight times each year, varying with the amount of rainfall and the character of soil.

Sulphate of ammonia is much slower in becoming available to the trees, and seems to be retained in the soil much more tenaciously than nitrate of soda, so that it need not be applied oftener than two to four times a year.

In the use of potash there is very little choice between the low-grade sulphate, which is also called the double salts of potash and magnesia, and the high-grade sulphate of potash.

In selecting phosphates, preference is given to dissolved bone or dissolved boneblack over dissolved rock phosphate, although some experienced orange growers consider the phosphoric acid derived from dissolved rock as good as that obtained from dissolved bone. Thomas slag has not been employed to any great extent in America.

PICKING.

In citrus growing, as in the growing of other commercial products, the agriculturist frequently does everything perfectly up to the time of harvesting his crop. He then gets in a hurry, and as a result of overhaste his product goes into the market in bad condition. This is especially to be regretted since so frequently his fruit is faultless when the time for picking arrives.

In picking citrus fruits the greatest care should be exercised not to include any imperfect specimens. The fruits should be separated from the tree by means of a clipper, cutting the stem off close to the fruit, leaving it smooth, so that when another fruit comes in contact with the cut stem it will not be injured thereby. The picked fruit should be placed in some sort of basket. Frequently the fruit is picked in sacks. While thousands of crates are picked in this way and the fruit is marketed in fairly good condition, first-class oranges in the prime of condition are apt to be either scratched or slightly bruised. Thoroughly ripe fruit is so filled with juice that it will spurt out if a thorn or the point of a knife blade be stuck through the skin. It must be taken to the packing house with the greatest care and permitted to cure before it is fit to pack. When the picker has secured as much fruit as can be conveniently put in a basket, it is turned into a field crate. These crates are usually of slightly larger size than the shipping crate, and so constructed as to make it possible to nest them for transportation to the packing house. After the fruit has been picked for some time and the skin has toughened and the fruit has been permitted to shrink to some extent, it may be handled with much less danger of being injured. This usually requires from three days to two weeks. At the end of this time the fruit is graded according to its appearance. This grading has to be done by hand, and requires the judgment of a man skilled in citrus sorting. Various names are given to the grades of oranges, such as brights, fancies, seconds, golden russets, russets, dark russets, and so on. Usually there are about three grades in a grove, the brights, golden russets, and russets. The brights are divided into fancies and seconds.

Lemons are picked while the color is green, the time of picking being governed by the size attained by the fruit. After picking it requires from one to several weeks to cure them properly for market. This is usually done in specially constructed houses, in tents, or in banks.

WASHING.

Citrus fruit grown on a tree free from disease and insect attack is usually in the most perfect condition possible. Its appearance can not be improved by washing or other mechanical process. But a very

large proportion is not grown under such conditions. Russet fruit is not improved in appearance by washing or scouring, but fruit affected by sooty mold should be put through a washer. Sooty mold is a black fungus (*Meliola*, various species) that grows in honey dew, usually excreted by some insect. The insect that most frequently produces the honey dew in Florida orchards is the white fly (*Aleyrodes citri*). Sooty mold very frequently follows an attack of the soft scale (*Lecanium* sp.), but this insect is usually very limited in distribution as compared with the white fly. The coloration of sooty mold being due to a fungous growth on the surface of the fruit, it becomes necessary to use some mechanical means for removing it.

Various machines have been invented for accomplishing this purpose. One in very general use has a series of brushes, slightly larger than scrubbing brushes, arranged on a chain belt. The fruit is received in single file down a chute, at the bottom of which is water in which the fruit is washed. The water and the brushes cause a very decided improvement in the color of the fruit. Another form of cleaner is constructed from a cylinder about 2 feet in diameter and about 4 feet long (see fig. 1). An axle in the form of a gas pipe is run through the axis of the cylinder, a crank is attached to this, and the cylinder is then mounted on a frame so that it can be revolved by hand. The inside of the cylinder is carefully padded with canvas. Fruit is placed within the cylinder until it is about three-fourths full; the remaining space is then filled with wet sawdust. By revolving the cylinder the wet sawdust wears off the sooty mold very quickly. When the fruit has been cleaned it is turned out and dried and is ready to be packed. The sawdust used for this work must be as soft as possible and must be sifted to free it from any large particles that might scratch the rind of the fruit.

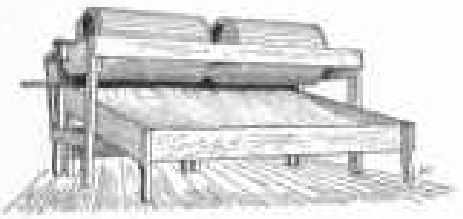

FIG. 1.—Homemade citrus-fruit cleaner used at Manavista, Fla.

SORTING.

After the fruit has been graded, it is run through a machine which separates it according to size. Various apparatuses are constructed for this work. One of the simplest is that made in the shape of a hopper with a chute running from it. This chute gradually increases in size, so that the fruits as they roll down drop into secondary chutes, which carry them into the field boxes from which they are taken to be wrapped. Lemons are usually picked when they have reached the desired size, which renders sorting for size unnecessary.

Another machine (fig. 2) makes a very satisfactory apparatus for sorting both oranges and pomelos. It is run by a treadle. The fruit is poured into the broad chute shown in the background and is allowed to run into two grooves. On the sides of these grooves, or runways, are long, thin cylinders provided with spirals. The runways as they pass away from the hopper widen, which permits the fruit to fall

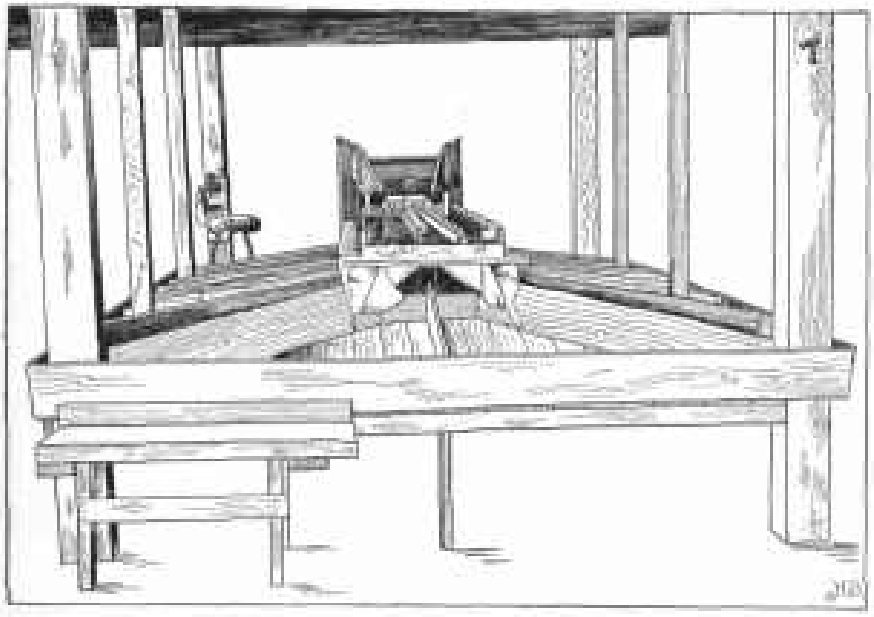

FIG. 2.—Machine for sorting citrus fruits.

through when the proper width is reached. The cylinders provided with spirals revolve so as to carry the fruit forward. On each side and in front are compartments for receiving fruit of each size. Immediately in the foreground is seen a bench for holding a crate into which the fruit is packed by hand.

WRAPPING.

The usual way of wrapping is by hand. This has been superseded in the larger packing houses by machines. The taste and care displayed in preparing the wrapping paper have frequently yielded good returns. In the large establishments wrapping paper having a suitable advertisement upon it, and often with a monogram or some other pleasing design, is used.

PACKING.

The packing may be done either by hand or by machinery. The greater quantity is packed by hand. The number of fruits and their

arrangement in the box have been carefully worked out so that each fruit is placed in mathematical order. The orange and grapefruit crates commonly used contain a space of almost exactly 2 cubic feet. The outside measurements approximate 12½ by 12½ by 27 inches. As these crates are manufactured and sold to the grower all ready to nail up, he need give this matter no special attention. In packing, the boxes are usually filled so that the last tier of fruit projects about one-half inch above the top of the box. After the box has been carefully packed, it is placed under a lever or screw press and the lid gently forced into position. This is then nailed down and strapped, and is ready to be stenciled for the market. The accompanying diagrams,

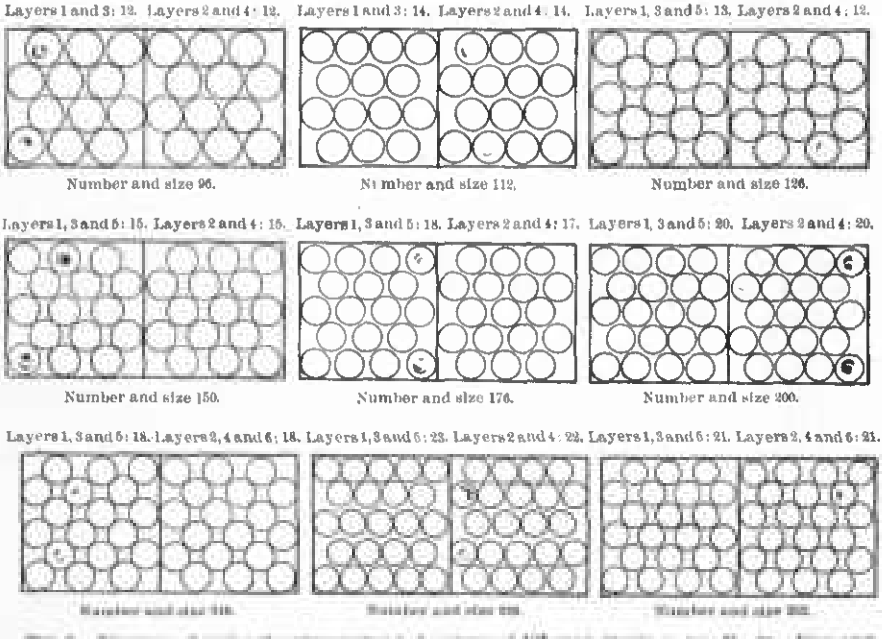

FIG. 3.—Diagrams showing the arrangement of oranges of different sizes in crates: No. 96.—Diameter, 3¼ inches; layers, 4. No. 112.—Diameter, 3⅛ inches; layers, 4. No. 126.—Diameter, 3 inches; layers, 5. No. 150.—Diameter, 2⅝ inches; layers, 5. No. 176.—Diameter, 2½ inches; layers, 5. No. 200.—Diameter, 2⅜ inches; layers, 5. No. 216.—Diameter, 2⅛ inches; layers, 6. No. 252.—Diameter, 2⅛ inches; layers, 6. No. 252.—Diameter, 2⅛ inches; layers, 6.

from Prof. H. H. Hume's Bulletin No. 63 of the Florida Agricultural Experiment Station, illustrate the arrangement of the fruit in the crates (figs. 3 and 4).

SHIPPING.

The moment the fruit is delivered to the transportation companies it passes out of the hands of the grower and beyond the possibility of his controlling the way in which it is handled. Not infrequently fruit put up in the very best condition and with the greatest care is slammed from the railway station into the car, and at its destination is again thrown from the car into a transfer wagon. Any-

one wishing to be convinced on this point has only to follow his shipment past the transfer station and to its destination on the market. The most careful packing and best of packages are none too good. To a certain extent the shipper of fruit is powerless in this matter, and very frequently the transportation company's officials are ignorant of the rough handling. The only way to correct these abuses is by vigorous protest and definite action. All transportation companies are sufficiently interested in the matter to see in a general way that the fruit is handled with a certain degree of care, but as long as no strong protest is made they take it for granted that everything is satisfactory. No matter how carefully and exactly the fruit is

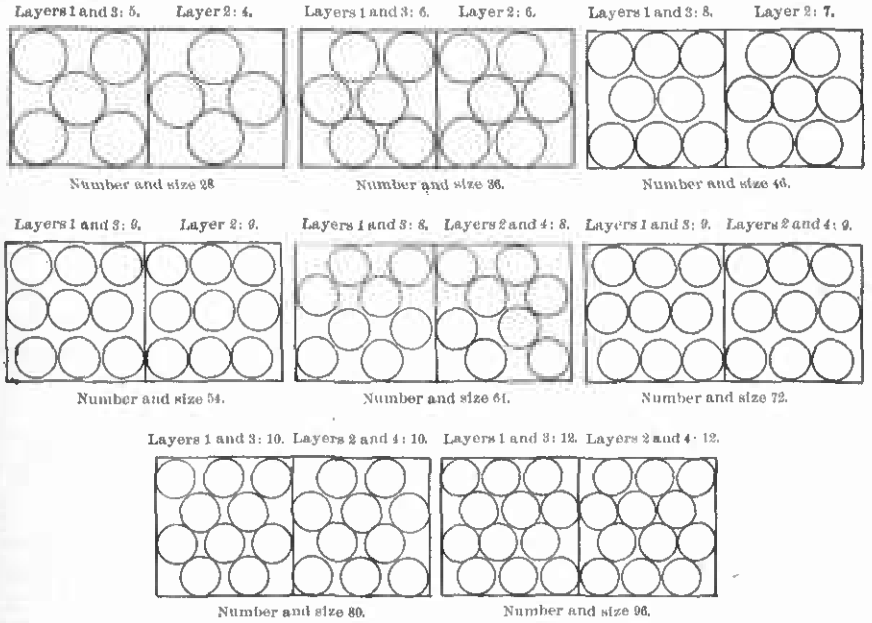

FIG. 4.—Diagrams showing the arrangement of pomelos (grapefruit) of different sizes in crates: No. 28.—Diameter, 5½ inches; layers, 3. No. 36.—Diameter, 5 inches; layers, 3. No. 46.—Diameter, 4¾ inches; layers, 3. No. 54.—Diameter, 4½ inches; layers, 3. No. 64.—Diameter, 4½ inches; layers, 4. No. 72.—Diameter, 4¼ inches; layers, 4. No. 80.—Diameter, 4 inches; layers, 4. No. 96.—Diameter, 3⅞ inches; layers, 4.

packed, if the packages are abused in transit the results must be disappointing.

STORING.

A great many attempts have been made to store citrus fruits. With the exception of the lemon, storage is not thoroughly successful unless the fruit is put in cold storage. Various methods have been suggested, such as packing the fruit in Florida moss, packing it in dry road sand, storing it in caves, etc. The results of experiments with all of these, however, have been disappointing.

In general it may be said that citrus fruits may be stored in a cool, dry place for two or three months without danger of serious loss. The temperature should not fall to the freezing point, and should not go much above 40° F. The air should also be dry enough to prevent moisture from forming on the fruit or packages during fluctuations in temperature.

In cold storage very fair success has been obtained in keeping the fruit, and when full information shall be at hand it will doubtless be possible to keep citrus fruits, at least in limited quantities, until the new crop comes in.

MARKETING.

The market selected for selling the fruit will vary with individual growers, the price being fixed by that obtained in the large markets, such as Chicago and New York. The price at the groves will be largely determined by the quantity of fruit supplied.

Where the fruit is sold on the trees, a definite written contract should be made, so that there is a full understanding as to the price to be paid for it, a date agreed upon at which all the fruit must be removed from the grove, and provision made for responsibility for injury to trees. The owner of the grove must expect to suffer more or less in the way of broken trees and limbs if the fruit is sold on the tree. Any unusual damage done to the trees, either by draft animals or by careless workers, should, of course, be borne by the person who buys the fruit and must be provided for in the contract.

A more satisfactory way of selling the fruit is at a definite price per box of a certain grade and size, delivered at the shipping station in first-class condition.

Usually the owners of small groves can not dispose of their fruit in the grove, but very frequently are able to sell it for a definite price at the shipping station. When the fruit is sold in this way, it is but fair and prudent to have a written contract giving full particulars as to prices, grades, sizes, and conditions. While much fruit is sold in this way, the great bulk of the fruit is shipped to the large markets to be sold. In such a case the grower should know to whom the fruit is consigned, having learned beforehand whether the sellers are responsible or not. While the determination of the financial responsibility of commission merchants or fruit handlers may seem difficult to the average grower, it is really a very simple matter to learn whether a business firm has any good reference or not. If the persons mentioned as references are addressed and no word is heard from them, it will be the safest course to assume that the reply would have been unfavorable.

PROTECTING TREES AGAINST COLD.

The disastrous freezes of 1894, 1895, and 1899 in Florida and the several minor cold spells that have destroyed a portion of the groves in California have caused the orange grower to cast about for some means of protection against a sudden cold wave. Two general methods have been practiced: The first is that of warming the air without providing shelter, and the second is that of providing a shed or shelter for the trees.

The methods of raising the temperature by means of fires, as described in the following paragraphs, can not be relied upon if the cold weather is accompanied by high winds or rainfall. In a portion of Florida during the heavy freeze of 1899 not only a heavy rainfall but heavy winds accompanied the cold. All attempts at building fires were useless, and even if they could have been built the wind would soon have carried the warm air out of the fields.

When a very moderate breeze is blowing and the temperature falls only 4 or 5 degrees below the danger point, fires on the windward side of a grove only need be lighted. The wind carrying the warm air across the other portion of the grove protects it from danger, and the constantly burning fuel keeps the air warm on the windward side.

PROTECTION BY HEAT.

Several forms of "heat protection" are advocated. The one in general use and of considerable value is that of heating the atmosphere by means of wood secured from the neighborhood.

Wood fires.—In a wooded country the form of protection against cold afforded by fires is cheap and at the same time very effective when a still cold occurs. The wood is piled in the centers of the squares, varying in quantity from three or four to a half-dozen or a dozen sticks of cord wood. When a freeze is predicted, the watchers notice the thermometer and by the time the cold approaches within 2 or 3 degrees of the danger point, which is 28° F. for fruit and 24° F. for foliage, fires are started in alternate squares. These will usually heat the grove some 4 or 5 degrees. If the cold continues to increase, all the piles of wood are started. It is of course necessary to have on hand a reserve stock of fuel in such an emergency. Shortly after the sun rises the next morning the temperature will usually have risen again, so there will no longer be any danger to the fruit or trees. If there is no favorable change in the weather, the cold on the second night is quite likely to be more severe than on the first. Firing then must be begun much earlier, and consequently a greater quantity of wood will be needed.

Coal baskets.—In California, Louisiana, and portions of Florida, baskets are made from heavy wire or heavy straps of iron which hold from eight to twelve quarts of coal. These are set about in the grove, much in the same way as wood is distributed. Late in the autumn, coal is placed in these baskets and covered with some cheap material, such as scraps of boards or palmetto fans, and is left in this condition. When the coal is to be used, a small amount of kerosene oil is poured into each basket, and the coal is lighted from the bottom. At times, wood from the southern pine, which is heavily impregnated with resin, is used as a starter in the bottom of these baskets. A supply of coal must be distributed in various parts of the orchard, and after the fires have been burning for some time the coal in the baskets is replenished.

PROTECTION BY IRRIGATION.

In the citrus-growing sections the water that is freshly pumped from the soil is quite warm, ranging from 50° to 74° or 75° F. When this water is carried through a grove in irrigating ditches, it gives off a considerable amount of heat, and has been used effectively in some instances where the temperature has fallen but slightly below the danger point.

Arrangements have also been made to throw this water into the air from spray nozzles. This is somewhat more effective than when the same quantity of water is carried through irrigating ditches, but can not be relied upon as being sufficient during extremely cold spells. During one of the recent cold waves the orchard of Mr. Theodore Mead, at Oviedo, Fla., was protected in this way one morning when the trees were covered with so heavy a coating of ice that some of the branches broke. The following summer the trees bore a crop of fruit.

The waters from artesian wells have also been used for the purpose of warming citrus groves, this water being quite warm, running into the sixties usually and as high as 74° F. in some wells. While this use of water does some good and protects that portion of the grove in the immediate vicinity of the large flow, the amount of heat given off is small and the volume of water supplied is not large enough to protect the grove to any considerable extent.

PROTECTION BY SHEDS.

The most successful method of protecting citrus trees from extremely cold weather is that of building a shed over the grove. At first thought this would seem to be entirely too expensive and not at all feasible, but the sheds have now been used long enough to demonstrate fully that they are not only possible but practicable. There are several modifications of the shed.

Sheds giving half shade.—Some of the orange sheds are modeled after the pineapple sheds of the east coast of Florida. These are light structures made of various kinds of lumber, usually such as can be obtained within a reasonable distance of the place where the shed is to be constructed. The essential parts of these sheds are the tops and sides. The sides, as a rule, are made a solid wall, while the tops, as the term indicates, give only half shade. Various materials are used for these tops, among the most common being plastering lath 4 feet long and 1½ inches broad (see fig. 5), and cypress slats 2 or 3 inches broad, one-half inch thick, and of lengths varying from 10 to 18 feet. Sometimes material 1 inch thick and 3½ inches broad and of varying lengths is used. The posts are usually 12 or 14 feet long, set into the ground 2 or 3 feet, at such distances apart as the length of the lumber would dictate. A very common spacing is to make the rows of posts 16 feet apart and 8 feet apart in the row. Planks 2 by 6 inches and 16 feet long are nailed to the tops of these posts, and where the cover lumber is 1 by 3 inches and 16 feet long these pieces are nailed across the

FIG. 5.—A shed giving half shade. (Grove of H. L. Ives, Cocoa, Fla.)

2 by 6 inch planks. Where plastering laths are used, planks either 2 by 2 inches and 16 feet long, or 1 by 3 inches and 16 feet long, are nailed on top of the 2 by 6 inch plank, and the laths are nailed to these latter stringers. Sometimes the plastering laths are woven by fencing machines between wires, and these are spread over the stringers. In all these cases the spacing between the roof material is just equal in size to the width of the material used, thus permitting one-half of the sunshine to pass through the slats; hence the term "half shade."

Sheds giving one-third shade.—Another form of shed in use is made more rigidly than the one previously described, and has a solid roof built over the entire area. This roof is made in sections about 6 feet wide running across the field, two-thirds of these sections being movable. Two movable sections are taken up in the spring after

danger of freezing is past, and are piled upon a third section, which is permanently placed. Under this arrangement the trees receive approximately two-thirds of the sunshine.

Sheds with removable tops.—Another form of shed is one in which the entire top is movable, and at the close of the winter all these tops are taken up and stored in a dry place.

Results obtained by using sheds.—All of these forms of sheds are more or less successful in accomplishing the end designed. The trees grow luxuriantly under these conditions and will endure freezes of a more severe nature than those experienced in the localities where the sheds are built. In the places where sheds are popular, the owners usually go to the additional expense of providing some form of heating apparatus. The tops being half closed or entirely closed, according to the type of shed, the heat is confined under this, and only a small quantity of fuel is consumed in keeping the temperature above the danger point.

Under the sheds which produce half shade, the trees usually grow very slender and produce only a comparatively small amount of foliage (see fig. 5), and on the whole produce a smaller crop of fruit. The fruit which is produced is of a superior quality, however, so that the reduction in quantity is compensated for by the improvement in quality.

PROTECTION BY TENTS.

In addition to the protection afforded by heating, irrigating, and the use of sheds, tents have been devised for protecting the trees against freezes. These are intended not as permanent structures but as a protection until the trees in the grove have become of such size as to afford a considerable protection to one another. Two forms of tent that have been used extensively possess considerable merit. One is a square or box tent, so called because of the shape of its base, and of sufficient height to take in the desired tree. In addition to this, kerosene lamps are provided, which are lighted on critically cold nights. On warm days one side of the tent is opened, so as not to overheat the atmosphere inside the tent, but to keep the tree dormant until spring arrives.

A circular form of tent is so arranged that by pulling a cord the tent closes automatically. When the weather becomes severely cold, lamps of suitable size are placed under these tents to keep the temperature from falling too low. As these tents are opened very easily, it requires but little work to open and close them; consequently they can be opened readily as soon as the danger of freezing is past. During summer they are taken down and stored in a dry place.

TOP-WORKING.

It sometimes happens that a grove is planted out to a variety that does not prove prolific, or one that may be unprofitable to market. In such a case it becomes necessary to abandon the grove or to top-work the trees. With the trees in a healthy and vigorous condition most or all of the top should be removed, only two or three vigorous limbs being left. Buds of the desired variety may be inserted into the limbs that remain. The mutilation of the tree caused by cutting away most of the top causes a heavy flow of sap into the smaller limbs which remain. In such cases the buds will "take" where they would fail if the top of the tree had not been vigorously cut back.

Another way of top-working is to cut away nearly all of the top and then wait for sprouts to start. After the sprouts have reached a

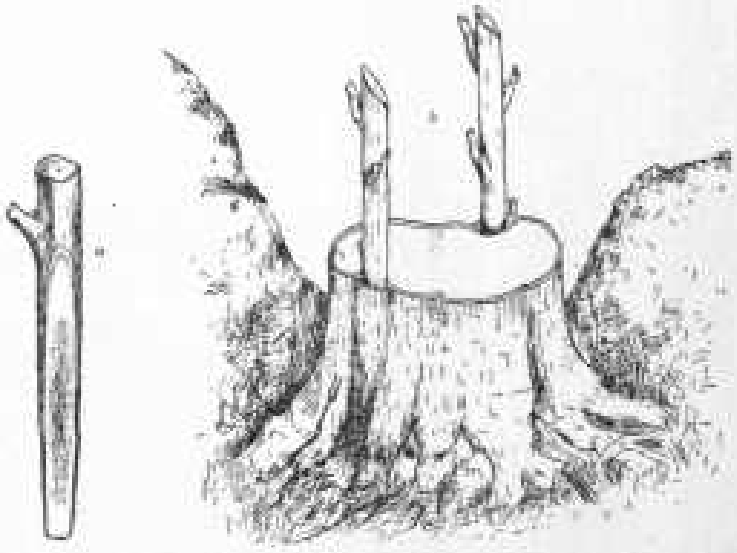

FIG. 6.—Method of crown-grafting an old orange stock; *a*, base of scion, showing slanting cut; *b*, method of inserting scion. (From Yearbook U. S. Dept. Agr., 1895.)

size of about half an inch in diameter they may be budded, and the bud will take readily. When trees have been cut back severely, the bodies and the larger limbs should receive a heavy coat of whitewash. This protects the trees against sun-scald.

Before top-working, the orchardist should be well acquainted with his grove and soil. In a very large portion of Florida severe top-pruning results in die-back unless proper fertilization and soil treatment accompany the work.

In California it appears to be safe to remove the entire top and to work buds into the large limbs. For top-working, the shield bud (see figs. 12 and 13) and sprig graft (see fig. 8) may be used to best advantage. In the latter case the sprig is placed in a large limb or branch.

CROWN-WORKING.

At times it becomes desirable not to permit the body of the t ee to remain. In such cases the trees may be cut off at the ground line. Some citrus trees, especially limes, resent treatment of this kind, and fail to grow after the top has been entirely cut off. The ordinary citrus stock, however, is almost certain to sprout again if treated in this way. Frequently large areas, 20 to 40 acres in extent, were sprouted in this way after the great freezes in Florida of 1894 and 1895 without the loss of a single healthy stump.

FIG. 7.—Ruby orange bud, put in May 21, on sprout from old sweet-orange trunk, as it appeared on October 25. (From Yearbook U. S. Dept. Agr., 1895.)

Trees that have been cut back in this way may be crown-worked or crown-grafted, as illustrated in figure 6, the sprig being inserted in the portion of the crown that will take it most easily. By slipping the scion into the portion of the crown where the bark may he raised without breaking, the work may be done without the use of wax or other binding material. After the scion has been inserted, moist earth should be raked over the crown and around the scion, covering them until they have "taken," and then exposing the tips. Where this work is done by experienced hands, only a very small percentage of the crowns fail in taking one or more sprigs. Those that fail to take may be worked again or left to produce sprouts and then budded into these sprouts. By using three or four such scions in a crown 4 or more inches in diameter and doing the work during February or the early part of March, the percentage of loss sustained will not be very great.

Another method of renewing such an orchard is to wait until the sprouts have started from the crown or the main roots. After these sprouts have reached a size of half an inch or so, buds are inserted as low down as practicable. In doing this, however, a considerable loss of time will be sustained iu waiting first for the sprouts to start and

then again in cutting them back to make the buds. The loss of time is strikingly illustrated by the two accompanying figures made from photographs (figs. 7 and 8).

THE NURSERY.

The nursery is the starting point of the citrus grove. It is, therefore, one of the factors of greatest importance. No matter how well the climate may be suited to the growing of fruit or how well the

FIG. 8.—Ruby orange crown-graft, put in March 1, as it appeared on October 23. (From Yearbook U. S. Dept. Agr., 1895.)

grove may be cared for after it is planted out, if improper selections have been made in the matter of stock or of buds, failure is just as certain as if improper selection had been made of the locality in which to grow the fruit.

SUITABLE STOCKS FOR DIFFERENT SECTIONS.

Each of the principal citrus-growing regions of the United States has a stock which is best adapted to its own peculiar conditions. Even in the larger citrus-growing regions the variations of soil are such as to demand a different kind of stock or bud. This discussion

has been partially covered in the section on varieties and in that on soil.

Louisiana and Mississippi.—In Louisiana and Mississippi the soil is a heavy clay, very fertile, and usually quite moist. Citrus trifoliata, or trifoliata, as it is commonly called, is preeminently the stock for use in this section. Here it not only is a vigorous grower but also imparts more or less of hardiness to the scion by becoming dormant in the autumn because of the fact that the trifoliata is a deciduous species (fig. 9).

Eastern north Florida.—In the eastern part of north Florida the trifoliata is also the best stock to use, for the reason given in the pre-

FIG. 9.—Citrus nursery at Naomi, La.: Trifoliata stock and mandarins to right; pomelos to left. Buds of one summer's growth.

ceding paragraph. Much of this region is also a rather heavy, sandy soil inclined to become clayey. In the deep, sandy portion of this section some of the more rampant-growing stocks do equally as well as or possibly better than the trifoliata, but they do not produce quite so hardy a tree.

Central Florida.—Throughout central Florida the soil is inclined to be sandy, but usually contains a considerable quantity of decaying vegetable matter. On this soil the pomelo stock does best, although it does not make quite so hardy a tree as the sour-orange stock.

South Florida.—The rough lemon is preeminently the stock adapted for use in south Florida. It is a rampant grower, able to live on soils

that are almost sterile for the other stocks mentioned, but is inclined to produce a little more coarse fruit than the other stocks. In the heavy soils of this section, especially that which is free from limestone, the pomelo and sour orange may be used to good advantage. These trees are somewhat slower in growth, but produce a more smooth and velvety fruit and ripen more evenly. The lime seedlings have also been used for stocks in this section. This makes a tree rather sensitive to cold, and the earliest crops of the fruit are inclined to be somewhat rough and thick-skinned. The greatest drawback, however, from the nurseryman's point of view, is that the ordinary operation that would make 90 per cent of the buds live in rough-lemon stock would probably not give more than 50 per cent in the lime stock. It is therefore used very little.

SELECTING SEEDS.

In selecting seeds from which to grow nursery stock, one should choose well-matured specimens. It is a matter of indifference as to the perfection or imperfection of the fruit from which the seed be taken, but the seed should be plump and well filled and the fruits taken from the most vigorous trees. This is true for all the varieties that are to be used as stock. One is frequently able to secure a lot of pomelo drops or fruits that have been frosted, and from these secure large numbers of fine seeds.

There are various methods of obtaining seeds from the fruit. Where fruit has been damaged and thrown out to rot, the seed may be washed out from the rotting mass and the superfluous water dried off. The seed may be separated fairly easily by using an ordinary sieve with large openings by forcing the water on to the seed by the use of a force pump or from a tank. In the case of trifoliatas and rough lemons the fruit is of no other value than for the seed which it contains.

After gathering these fruits they are cut into sections with a dull knife and most of the seeds pressed out, and the cut sections are thrown into a barrel and covered with water. In a short time this mass will be sufficiently disintegrated to allow easy separation of the seed. Care must be taken, of course, not to let the material remain in the water sufficiently long to injure the seed. If the barrel is placed in a warm location, in three or four days the seeds will slip out easily, and they can then be separated from the pulp by washing.

The seeds that are squeezed out by hand need no special washing. They should be placed in the open in a shed to allow the superfluous moisture to dry off, and then are ready for preservation. Bonavia says that in India the seeds "are well dried in the sun for two or three days."

KEEPING SEEDS.

In the northern sections of the citrus-growing regions the seed must be kept for a considerable time before the ground is sufficiently warm to receive it. After the superfluous moisture has dried from the seeds, which will occur in the course of from one to three days, they may then be preserved in dry sand.

Where sand is not readily obtained, a fairly dry clay, such as will break up readily, and not sufficiently moist to pack, will be found useful. In this kind of material the seeds of trifoliatas have been shipped from Japan to Florida and have retained their germinating qualities perfectly.

PREPARATION OF THE SEED BED.

Where only a few thousand seeds are to be planted they may be germinated in boxes or trays. Taking a box which is about 8 or 10 inches deep, with its other dimensions of convenient size, 3 or 4 inches of soil is placed in the bottom. The seed may then be sown on this layer of soil, and an inch more of soil placed over the seed. Over this a layer of mulching, such as decayed leaves or sphagnum, or in fact anything that will keep the soil from drying out, may be placed, and in this the seed may be allowed to germinate and seedlings grown. The mulching should be removed as soon as the seedlings begin to come up.

The ordinary seed bed, or cold frame, as it is usually prepared by gardeners, is also an excellent place to germinate the seed and grow seedlings. In planting in beds of this kind the rows should be made 6 inches or a foot apart, and the seeds dropped 1 or 2 inches apart in the row. They may be left there until they have grown sufficiently large to be planted out in the nursery.

For growing seedlings on a large scale where hundreds of thousands are to be grown, it becomes necessary to make a careful selection of the spot where the seeds are to be planted. A place that is not in danger of being flooded or becoming too wet, and yet that will remain constantly moist, should be chosen. This land should be thoroughly broken up, plowed deep, especially if it is of a heavy or clayey nature, the rows laid off from 2 to 4 feet apart according to conditions, and the rows then opened up and a liberal application of fertilizer made. If the site happens to be a clay soil, it is well to break the rows at least 10 inches deep. Fertilizer is then scattered down the rows and worked in thoroughly by the usual farming implements. From two weeks to a month or so after the seed bed has been prepared in this way the seed may be sown. The furrows are thrown open 5 inches deep and the seed scattered down the rows, being sufficiently distributed to give each seed an inch or so of space. The rows may

be made from 4 to 8 inches wide according to the needs and conditions. The seeds are then covered about an inch deep and the soil firmed about them. If drought follows the planting, it may become necessary to resort to watering to keep the seed from drying out.

TIME OF SOWING.

The best time to sow depends upon the location of the seed bed. In southern Florida and the West Indies the seed may be sown as early as December. In central and northern Florida, and in Louisiana, Mississippi, and California, it is better to wait until the soil is warmed up sufficiently to induce rapid germination and active growth. This time may be reached anywhere from the first of February until about the middle of March or later, varying in different seasons and in different localities.

CULTIVATION OF THE SEED BED.

The cultivation of the citrus seed bed is the same as that usually given to seeds of garden crops. At first light working, such as may be done with a garden rake, will be most useful. A skillful laborer may rake over a seed bed when the seedlings are coming through the ground with entire safety to the small plants. This raking may seem quite useless in many instances, but it is very important in that it conserves the soil moisture and breaks the crust if there is any tendency to form a hard surface. The middles may be cultivated with the usual shallow-going farm tools—a spring-tooth cultivator, a special harrow, or a hand plow. Cultivation should be repeated every week or ten days, and as the seedlings grow stronger the cultivation in the clay soils should be made deeper, until in midsummer or early autumn it has reached the maximum depth of farm cultivation. On the sandy lands cultivation should never be more than 3 or 4 inches deep, for on such lands the soil is already sufficiently loose and further stirring does not add to its productiveness.

TRANSPLANTING

Under favorable conditions the seedlings will have attained a height of from 6 to 12 inches and the diameter of a small pencil by autumn or by the next winter. The seedlings are then in good condition for transplanting. The time of transplanting is less definite than that of sowing the seed. In the West Indies and southern Florida transplanting may be done with good success any time after the seedlings are of sufficient size, depending on the favorable condition of the soil. In other citrus-growing regions transplanting is done in the spring or early summer, whenever favorable climatic conditions occur. Under

some conditions seedlings are permitted to remain in the seed bed for nearly two years.

In preparing for transplanting on a large scale the nurseryman frequently uses a tree digger to run under the seedlings. This loosens up the ground on both sides, and at the same time cuts most of the taproots. The depth to which the tree digger should be run will depend on the amount of root growth the seedlings have made. In heavy soils transplanting is much facilitated by plowing a deep furrow on each side of the seedling row. A heavy spade may then be inserted under the row, and the seedlings lifted without much damage to the root system. Some means for keeping the roots moist after they have been removed from the ground should be provided.

PREPARATION FOR THE NURSERY.

The location of the nursery is of very considerable importance. The land selected can usually be slightly more moist than such as would ordinarily produce a good grove, but to be successful it should not be subject to flooding, nor should it be subject to drying out during severe droughts. The rows should be laid off from 4 to 6 feet apart, thoroughly broken out to a considerable depth, say, about 10 inches, and then prepared in the usual manner in which gardeners prepare their land for vegetables.

Thoroughly rotted stable manure will be found an excellent fertilizer in heavy clay soils. In the soils that are inclined to be sandy, commercial fertilizers will be found of greater advantage. The quantity of manure and fertilizer to be used will depend on the fertility of the land to be planted. Upon the ordinary sandy soils from 500 to 1,000 pounds of the formula previously recommended will be found entirely sufficient for the first application. On rich clay soils well-rotted stable manure at the rate of several loads to the acre will be found sufficient.

The rows should be prepared thoroughly and the land made ready about a month before the probable time for setting out the nursery stock. After the land has been prepared it will be no special harm if one has to wait longer than was expected before a favorable time for transplanting arrives.

When the time for transplanting arrives the seedlings may be taken out of the seed beds and transplanted into the nursery rows in various ways. The trees should be set about a foot apart in the row. Many nurserymen prefer to use a thin spade for transplanting, running this into the ground, bending it over, and setting the tree in. In this operation one man uses the spade while another man inserts the tree. When the spade is withdrawn, each man presses a foot near the tree and firms the soil tightly about it. In other cases the nurseryman

prefers to simply run a furrow or double furrow down the row, set the tree firmly into position by hand, and then fill in the soil with a plow.

In setting the seedlings they should be placed so that the level of the soil is approximately at the same height on the seedling as when it grew in the seed bed. If the trees happen to be set an inch or so lower it will be of no serious disadvantage. In this work of transplanting, all small and inferior seedlings should be thrown out, as in all probability they will make only second or third rate nursery stock and will prove to be poor trees in the grove. What is wanted of nursery stock is a tree that has vigorous growth.

CULTIVATION OF THE NURSERY.

The cultivation of the nursery may begin immediately after the seedlings are set out. The cultivation at first need not be deep, merely running over with the finishing tools to conserve the moisture and keep the ground in good condition. Where the soil is sandy the cultivation at no time need be much more than this. In the heavy clay soils it is important to break up the soil as deeply and thoroughly as possible. The length of time elapsing between repetitions of cultivation will depend upon the conditions of the soil. In all of the work of cultivating citrus trees it should be remembered that the destruction of weeds is of secondary importance. Of course this should never be neglected, but the real value of cultivating lies in the fact that the soil is kept in a suitable condition of aeration. If a heavy, beating rain falls immediately after cultivating, much of the good effected by the work is lost, and consequently another cultivation should be made as soon as the soil conditions will permit.

SEEDLING GROVE.

In the early history of citrus growing main reliance was placed upon the propagation of trees from seed. Such trees, when grown to fruiting age, are usually spoken of as seedlings. The use of seedling groves has been almost entirely superseded by budded groves. At the present time very few seedling groves are being planted out. If one wishes to secure a seedling grove it is of the utmost importance to make a careful selection of the fruit from which the seeds are taken. Care should also be exercised not to use seeds from groves in which occurs a mixture of citrus varieties. The seedlings from such a grove will produce an exceedingly variable crop. Certain minor variations will occur in every orchard, however, no matter how carefully the trees may have been selected. In planting out a grove of this kind there is no certainty as to the quality of the fruit or the bearing propensities of the trees.

Another disadvantage of planting seedling groves is that such trees are later in coming into bearing than budded trees, and as a rule are of a more upright growth. The vigor of seedling trees is usually greater than that of the ordinary budded grove, but this is practically the only strong argument in favor of a seedling grove.

PROPAGATING BY CUTTINGS.

Lemons, limes, pomelos, and other citrus species propagate very readily from cuttings. The cuttings are taken from fairly matured wood and at such time of the year as will give considerable moisture to the soil and at the same time considerable warmth. While these cuttings have been employed for producing nursery stock on which to bud they are not nearly so satisfactory as seedlings, the growth being somewhat slower and not as straight and satisfactory for budding as when seedlings are used. Root cuttings from these various species may also be employed, but these have the same disadvantages that are encountered with the use of cuttings from the branch.

BUDDING.

There are various methods of propagating citrus trees—by budding, grafting, or inarching. While there are conditions under which grafting becomes necessary, and inarching must be practiced to obtain the desired end, budding is preeminently the best method of propagating citrus trees. The work is done so easily and may be accomplished with such certainty of good results that grafting and inarching as methods of increasing the stock of any particular variety must be considered obsolete.

The subject of budding was well covered by Dr. H. J. Webber in his paper entitled "Methods of Propagating the Orange and Other Citrus Fruits," which appeared in the Yearbook of the United States Department of Agriculture for 1896, and as no important improvements have been made since that date the following chapters, with the exceptions of those on time of budding and on cutting buds, are quoted without any modifications.

TIME OF BUDDING.

In regions where a more or less definite winter occurs, budding is practiced either late in the autumn, about November or December, and called dormant budding; or in the spring, after a vigorous growth has started. Good citrus stock may be budded at almost any time of the year, except during the winter in those sections where a decided lowering of the temperature occurs. In general it may be said that

buds may be inserted at any time of the year when the bark of the stock separates easily from the wood. This always indicates a strong flow of sap.

CUTTING BUDS.

Some experienced nurserymen prefer to cut the bud sticks and keep these for a few days, or several weeks, before inserting the bud. It is thought by them that a larger percentage of the buds will take under these conditions.

SELECTING BUDS.

Bud wood should always be selected from fairly well-matured wood of the current year's growth. Round sticks (or as nearly round as possible) should be selected. The young growth of orange wood is at first angular, becoming rounder as the twig matures. The basal portions of the young branches, which are nearly or quite round (fig. 10, *a*), supply the best buds, with the exception of the first two or three, which are usually somewhat imperfect and should be discarded. Where it is difficult to secure well-rounded wood, angular wood which is not too soft (fig. 10, *b*) may be used. This, however, is not quite so satisfactory. Thorny bud wood should never be used when other wood can be obtained. Thorny trees are very undesirable, and a careful selection of thornless bud wood will soon result in thornless trees. The thorns have been bred out of many of the best citrus varieties, and if nurserymen would exercise proper care all the desirable varieties could soon be rendered thornless.

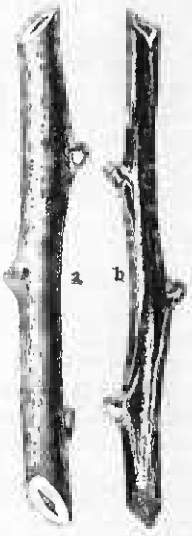

FIG. 10.—Sweet-orange twigs: *a*, round twig of select buds; *b*, angular twig of buds. (From Yearbook U. S. Dept. Agr., 1896.)

After cutting, the leaves should be pruned off and the twigs cut into sections of the desired length. To preserve the bud wood until needed the twigs should be tied up in convenient-sized bundles, carefully labeled, and packed in old sawdust in a box of suitable size. The box should then be closed and buried in sheltered ground several inches below the surface. In this way bud wood can be preserved in good condition for from two to three months. Dampened sphagnum, or peat moss, may be used instead of sawdust, but in this case considerable care must be exercised to get the moss properly dried. It must be moist, but not wet, for if too wet the bud wood may mold. The same caution applies also to sawdust. In this case the proper degree of moisture can be secured by taking the material from the interior of an old pile. Sawdust does not lose its moisture readily and is the best material for packing. Some simply bury the bud wood in the soil under shelter, digging down until the moist earth is reached.

MATERIALS FOR BUDDING.

Before beginning the operation of budding, material should be provided for wrapping the buds. For this purpose cotton cord, yarn, strips of waxed cloth, etc., are used. The last named has practically superseded all others in Florida, being more convenient and giving better results than any other wrapping material. The strips are made from strong muslin or calico. Before the cloth is torn into strips, it is

folded into convenient size and dipped into a hot solution of wax made by melting together two parts of beeswax and one part of resin. Several formulas for making this wax are used, any one of which will probably answer. The method described is known from personal experience and observation to give good results. After saturating the cloth with the hot wax, all the superfluous wax should be removed before the cloth cools. To accomplish this quickly hang the piece of cloth, folded in convenient form before waxing, over a small, strong stick (fig. 11, *a*), which is held by an assistant. Then take two similar sticks of wood, and holding them parallel on either side of the cloth (fig. 11, *b*), press them firmly together and pull downward, squeezing out the superfluous hot wax. The cloth should then be spread out until cool, after which it is ready to be torn into strips of the desired size—that is, one-fourth to one-half inch wide and from ten to twelve inches long. The cloth may be torn into strips before it is taken into the field, or it may simply be torn into convenient-sized pieces and afterwards torn into strips in the field as desired for use. The latter is probably the most convenient way.

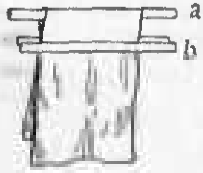

FIG. 11.—Method of removing wax from budding cloth. (From Yearbook U. S. Dept. Agr., 1896.)

Using waxed cloth for wrapping effectually excludes moisture, prevents the bud from drying out, and the work can be done more quickly than with string, as the strips cover more surface and do not require tying, the wax serving to hold the cloth firmly in place. It may therefore be recommended as far preferable to any other wrapping material.[a]

HOW TO BUD.

Budding is a simple process, consisting in inserting a bud of a desired variety under the bark of the stock in such a way that the freshly cut inner bark of the bud comes in close contact with the layer of growing wood (cambium) of the stock. The bark is closed over the inserted bud and the stock wrapped with waxed cloth, as described, so that the bud is firmly pressed against the growing wood. If the operation is properly performed, the tissue of the bud and stock soon fuse together and the bud may be forced to grow.

In all varieties and stocks of citrus fruits the process of budding is practically the same, the method commonly employed being that known as shield, or eye, budding (fig. 12). The bud is inserted in the young stock near the ground. Previous to the severe freezes of the winter of 1894–95 the general practice was to insert the buds 12 to 18 inches above the ground, but since then the tendency is to bud as near the surface of the soil as possible, so that the trees may be readily banked with the earth above the bud to protect against injury from

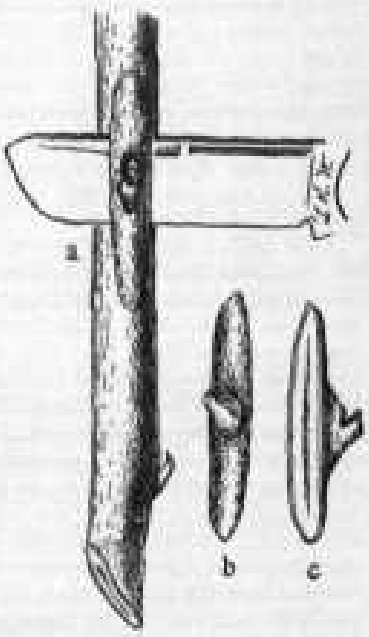

FIG. 12.—Shield, or eye, buds: *a*, method of cutting bud from round twig; *b*, bud cut ready to insert; *c*, face of bud showing the cut surface. (From Yearbook U. S. Dept. Agr., 1896.)

[a] The choice of wrapping material is an individual and a local affair. Some nurserymen use only raffia and have nearly perfect success; other nurserymen use only cotton wrapping twine and their buds take almost perfectly. These are located in the moister sections where buds are not apt to dry out.—P. H. R.

freezes. Most of the buds are now inserted from 2 to 6 inches above the soil. In sections where foot-rot is abundant and sour-orange stock is used as a preventive measure the buds should be inserted from 12 to 18 inches above the soil, so that the sweet-orange wood will be above the influence of the disease.

All leaves and limbs which would hinder the proper wrapping of the buds should be cut away with a sharp budding knife. The use of sharp tools is the secret of success. A vertical cut about 1½ inches long is made at the point where the bud is to be inserted. At the base of this a horizontal cut is made, so that the two cuts present the appearance of an inverted T (⊥), as shown in fig. 13, *a*. The cuts should not be deep. The aim should be to merely cut through the bark, but no injury will result if the cuts are rather deeper. The lower edges of the bark are slightly raised with the end of the knife blade (fig. 13, *b*) to facilitate the insertion of the bud. This may also be accomplished by giving the knife an upward turn after making the horizontal cut. Now, take a stick of bud wood in the left hand and cut out a bud,

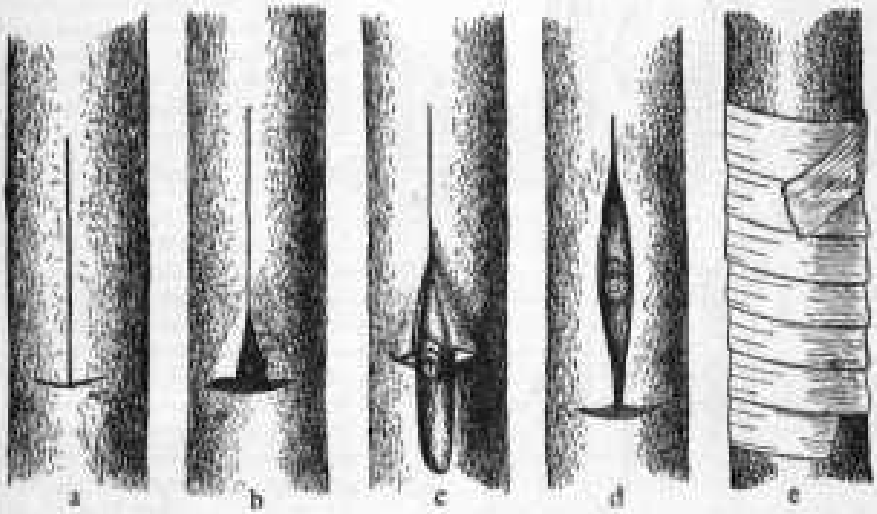

FIG. 13.—Shield, or eye, budding: *a*, incision on stock; *b*, incision with lower ends of bark raised for inserting the bud; *c*, bud partially inserted; *d*, bud inserted ready to wrap; *e*, bud wrapped with waxed cloth. (From Yearbook U. S. Dept. Agr., 1896.)

as illustrated in fig. 12. Formerly the portion of the wood cut out with the bud was removed, but experience has shown that this is entirely unnecessary. The upper end of the bud is inserted under the slightly raised ends of the bark (fig. 13, *c*) and gradually pushed upward until all portions of the cut face of the bud come in contact with the wood of the stock (fig. 13, *d*). If in proper condition for budding, the bark of the stock readily separates, allowing the bud to be pushed upward into position. The bud is now ready to wrap. Take a strip of the waxed cloth prepared as above, and beginning slightly below the horizontal cut wrap tightly around the stock over the bud in a spiral manner, each turn slightly overlapping the previous one. The wax holds the cloth in place and makes it possible to draw it very tight. When the vertical incision has been entirely covered, turn the end of the strip slightly downward over the wrapped portion, to which it adheres more firmly than it would to the bark, and no tying will be necessary (fig. 13, *e*.) It is better to wrap from below upward, as in this case each turn overlaps the other in the right direction to prevent water running down the stem from entering. Nurserymen usually

wrap over the bud, covering it entirely. Some, following the practice commonly used with other fruits, leave the eye of the bud exposed. This, however, is more troublesome and does not succeed so well.

In some cases where bud wood of certain varieties is difficult to secure, it may be desired to use buds from the young angular wood (fig. 10, *b*). This may be used with good results if the stock to be budded is growing rapidly and is in a succulent condition. In this case the method of cutting and inserting the bud is slightly different from that already described. In cutting the buds the stick is turned slightly to one side, so that as the bud is cut off the eye lies on one side instead of in the center of the bud (fig. 14, *a*, *b*, and *c*). It is only by cutting the bud in this way that the cut surface is made wide enough to hold the bud firmly in position. For inserting these buds an incision is made in the bark, as shown in fig. 13, *a*. The bark is slightly raised on one side with the point of the knife and the bud is slipped under in a lateral direction, the eye remaining in the vertical slit (fig. 14, *d*). The bud is then wrapped as shown in fig. 13, *e*.

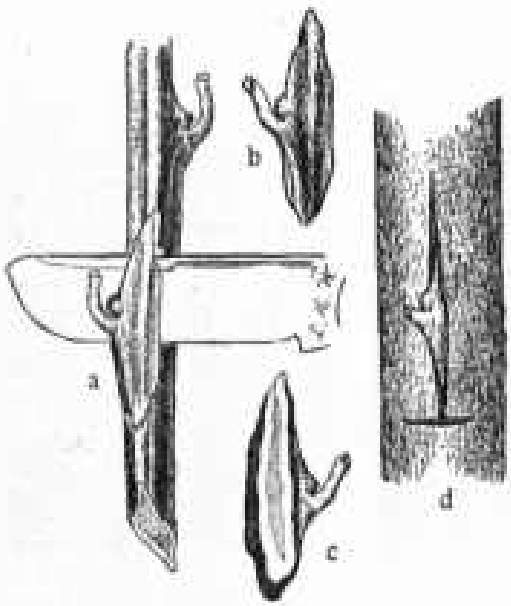

FIG. 14.—Shield budding with angular wood: *a*, cutting the bud; *b*, bud cut ready to insert; *c*, bud showing cut face; *d*, bud inserted, bark on right side only being raised. (From Yearbook U. S. Dept. Agr., 1896.)

UNWRAPPING THE BUDS.

In from ten to twelve days the buds will have united with the stock and may then be unwrapped. In early spring, when the weather is cool and the growth slow, the wrapping should be left on from fifteen to twenty days, while in the summer when the weather is warm and the growth rapid, ten days is usually a sufficient length of time. However, it is impossible to say definitely how much time should elapse before the wrapping should be removed, as the wood of the stock should never be allowed to grow over the buds. It should not be removed until a light grayish line of new tissue can be seen forming around the edge of the incision made in inserting the bud. A little experience will enable one to tell at what stage it is safe to unwrap. Under ordinary conditions from twelve to fifteen days will give good results, but in very dry weather in the summer, when growth is slow, it may be necessary to leave the wrapping on for a longer time. Some ten days after budding an examination should be made of a number of the buds, and if they are found to be well healed on, the wrapping may be taken off; but if not, the wrapping should be replaced and allowed to remain some time longer. If the wraps are allowed to remain too long, the wood of the stock is likely to grow over the buds and greatly hinder their pushing.

FORCING THE BUDS.

In order to force the buds to push uniformly after they have healed on, it is necessary to severely check the growth of the stock. This is most commonly accomplished in nursery trees by lopping the tops, as it is called, which is usually done

from three to five days after the wraps are removed from the buds. The lopping is usually done with pruning scissors, the knife-edge being placed about 2 inches above the bud and the stock cut two-thirds through. The top is then bent over to one side and allowed to rest on the ground (fig. 15, *a*).

To provide for subsequent cultivation and attention it is necessary to use some definite plan of budding and lopping in the nursery. Two methods most commonly followed by Florida nurserymen are to lop the tops of two adjoining rows into the same center (fig. 16, *a*), keeping the alternate centers free for cultivation, or to lop the tops of alternate rows in different directions, one row in each center (fig. 16, *b*), and place them near the rows. By the latter method a cultivator may be run up one row and down the other, passing always in the direction in which the tops are inclined so that the branches will not interfere with the cultivator. Usually the old tops are allowed to remain attached until the buds have attained a height of from 12 to 18 inches, after which they may be cut off.

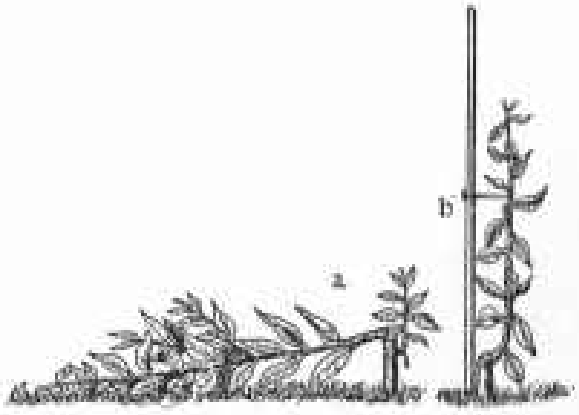

FIG. 15.—Treatment of buds: *a*, young tree lopped to force bud; *b*, bud and supporting stake after "lop" has been removed. (From Yearbook U. S. Dept. Agr., 1896.)

Some nurserymen have found that the buds make a larger growth if the old tops are allowed to remain attached through the summer and are cut off in September. If this practice is followed, two rows of trees should be lopped together. The tops thus form a dense shade or sort of mulch on the soil, keeping it moist and preventing the weeds from growing. In this case it is also desirable that the rows lopped together should be planted rather close (about 3 feet apart), for if this is not done the weeds will grow up among the tops, making it necessary to cut off the latter when the buds are 1 foot to 18 inches high in order to keep the weeds down. In the case of vigorously growing stocks, like the rough lemon, it is said to be very desirable to leave the tops attached for some time.

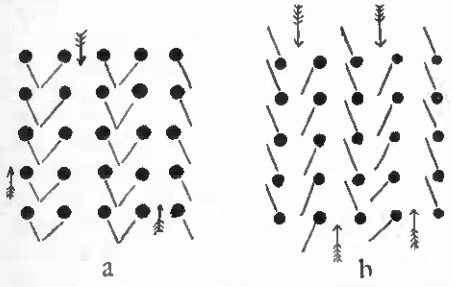

FIG. 16.—Diagrams illustrating methods of lopping nursery trees: *a*, lopping two rows in one center, leaving alternate centers free for cultivation; *b*, lopping alterate rows in opposite directions. (From Yearbook U. S. Dept. Agr., 1896.)

When the old tops are removed, the portion remaining above the bud should be cut off smooth and close to the bud, so that it will soon heal over without forming an ugly scar (fig. 15, *b*). Some follow the practice of coating the freshly cut end with shellac, but others working on an extensive scale never do this. It is seldom that any noticeable benefit is derived from the practice.

GROWTH OF THE BUDS.

The attachment of the rapidly growing bud is at first very weak and it is necessary to strengthen it by tying to a stake (fig. 15, *b*). Some nurserymen practice cutting the stock rather high in lopping, and support the buds for a time by tying them to the remaining portion of the stock. The buds push much better, however, when the stocks are cut very close in lopping, so that it is hardly desirable to depend upon this method of supporting the buds, as in either case it is necessary later to supply the supporting stakes. (See figs. 15 and 17.)

FIG. 17.—Arrangement of stakes in a nursery. (From Yearbook U. S. Dept. Agr., 1896.)

The development of the buds should be carefully watched during summer, and they should be pruned in such a way as to produce a top of the desired shape. In Florida, where a low tree is desired, it is necessary to nip the tops when they are 2 or 3 feet high to induce branching. The buds which push low down on the stock or bud should be rubbed off before they have grown to any size, as their growth detracts from the development of the bud.

DORMANT BUDDING.

Putting in buds which are intended to remain dormant during the winter, or dormant budding, as it is called, is usually done in October or November. The process is exactly the same as described above, except that the tops are allowed to remain standing until the following spring. They are lopped in the usual manner the latter part of February, or just before the spring growth starts. The advantage of dormant budding is to secure the first spring growth in the bud, which is the largest growth in the year.